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Research Article
Morpho-Biometric Evaluation of the Genetic Diversity of Local Chicken Ecotypes in Four Regions (Centre-East, Sahel, Centre-North and South-West) of Burkina Faso

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Abstract

Background and Objective: Local chickens in Burkina Faso play a crucial role in income generation and food security, especially to the rural community and the most vulnerable groups. Genetic and phenotypic characterization of these local chicken ecotypes is sketchy. The objective of this study was to determine the morpho-biometric characteristics of local chicken "Konde" from the Centre-East and local ecotypes in the Sahel, Centre-North and South-West regions of Burkina Faso. **Materials and Methods:** A total of 1179 adult local chickens at six months of age were used for the study and sampled as followed: 406, 352, 285 and 136 chickens respectively from South-West, Centre-North, Sahel and Centre-East region. **Results:** The mean body weight of chicken was 1204.80±344.9 g and significantly affected by region and sex ($p<0.05$). Konde Chickens (1651.85±378.57g) were heavier than those of the birds from the Centre-North (1163.66±259.39 g) and South-West regions (1217.92±322.31 g), which did not differ from each other but they were heavier than those of the birds from Sahel region (1023.59±250.99 g). For all ecotypes, males were significantly heavier (Konde = 2006.27±412.17 g; Centre-North = 1301.28±269.90 g; Sahel = 1123.82±294.22 g; South-West = 1470.35±349.62 g) compared to female (Konde = 1498.89±234.74 g; Centre-North = 1080.08±213.67 g; South-West = 1096,31±223,17 g; Sahel = 956.77±190.98 g). The multivariate analysis revealed three types of (03) populations: large heavy chickens (1976±273 g), medium chickens (1296±163 kg) and small light chicken (909±119 kg). Dominant plumages were white (15.86%), partridge (11.96%), multicolors (11.79%) and hermine (10.09%). Naked neck, curly plumage, yellow legs, crested and rose comb mutations were identified in the studied ecotypes. **Conclusion:** Data from this study shows sufficient phenotypic variability in moderately heritable traits supporting the possibility for genetic improvement of local chicken ecotypes in Burkina Faso.

Key words: Body weight, chicken Konde, morpho-biometrics, Burkina Faso

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

In developing countries, local or backyard poultry production is an important source of dietary animal protein, a major source of income generation and cash flow for small-scale producers and vulnerable groups (women and children). In Burkina Faso, the poultry population is estimated at around 44 million birds of which are 76.3% chickens, 19.2% guinea fowl, 3.7% pigeons, 0.7% ducks and 0.1% turkeys[1]. In the rural communities of Burkina Faso, poultry farming plays an important socio-economic and cultural role[2-4]. Local poultry products are more appreciated by the population than those of exotic breeds[5-7]. In Burkina Faso, for a sustainable food security system[1,8], seven (07) local chicken ecotypes had been identified by Ouandaogo cited by Keambou *et al*.,[9]: (a) The Dori chicken and the Peul (Fulani) chicken, in the northern Sahel zone, (b) The dwarf chicken, the curly chicken and the naked neck chicken in the South-West region; the Centre chicken in the Centre region and (c) the Konde chicken, in the Centre-East region of Burkina Faso. There is limited to no information on the genetic and zootechnical characteristics of local chickens in Burkina Faso. In fact, studies on the characterization of local chickens in Burkina Faso did not take into account the endangered ecotype "Konde" of the Centre-East region[10]. Such information is needed for the maintenance of the genetic diversity and could highlight the potential of Konde ecotype in an appropriate genetic improvement program[6]. The present study falls within such priority and contributes to a better knowledge of local chickens in Burkina Faso. The overall objective of the study was to determine the morpho-biometric parameters of the local chicken ecotypes in four regions of Burkina Faso (Centre-East, Sahel, Centre-North and South-West).

MATERIALS AND METHODS

Study areas: The study was carried out in three agro-ecological zones of Burkina Faso[11] and covered at least one region in each (Fig. 1). The Séno province (14°00'N) in the Sahel region is located in the Sahelian agro-ecological zone with an average annual rainfall between 400-600 mm. The study took place in the communes of Dori, Bani, Gorgadji and Seytenga. In the Centre-North region, the study was carried out only in the Sanmatenga province located between parallels 11°30' and 14°00'N, with an average annual rainfall of 600-900 mm. The region is characterised by a Sahelian and a Sudano-Sahelian climate and the data collection sites were Kaya, Namissiguima and Barsalgo. The Centre-East region is characterized by two types of climate: the Sudano-Sahelian climate with an average yearly rainfall of 600-900 mm and the Sudanian climate with an average rainfall of over 1000 mm per year. In this region, data was collected in three communes in

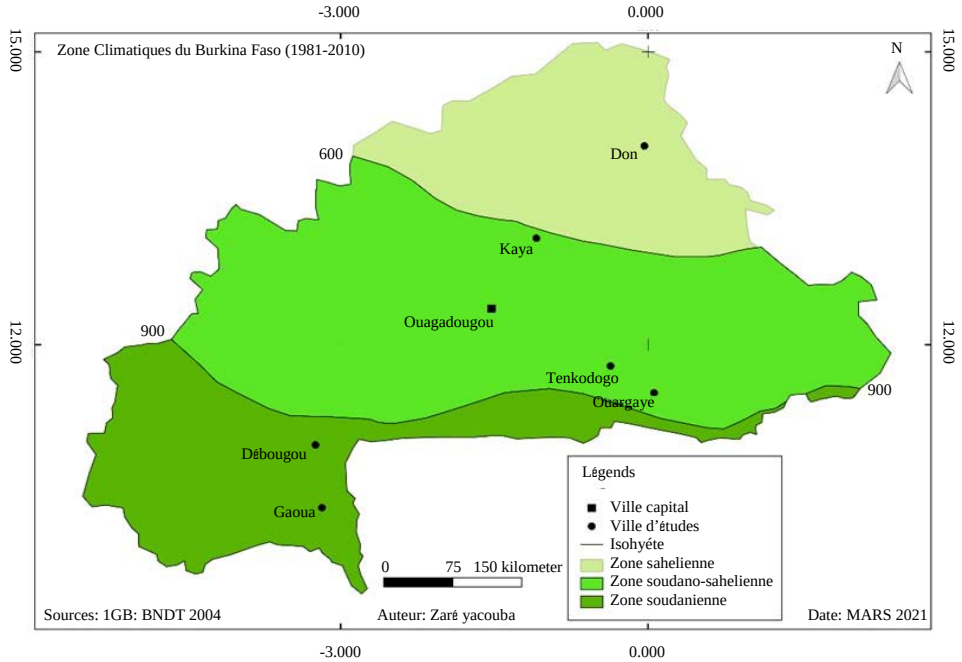

Fig. 1: Map of study areas (IGB-BNDT, 2014)[12]

the province of Boulgou (Tenkodogo, Garango, Zabré) and one commune in the province of Koulpélogo (Ouargaye). The South-West region is located in the Sudanian zone south of the 11°30' parallel. Data was collected in the provinces of Bougouriba and Poni. In Sudanian, the average annual rainfall is 900 to 1,200 mm and average temperature is 27°C, ranging from 21-32°C.

Data collection and sampling: The data was collected from 5 March to 10 June 2019. A total of 270 farmers were included in this study (at least 50 farmers per region). A total of 1179 adult birds (males and females) of at least 6 months of age were used with 285, 352, 406 and 136 birds from the Sahel, the Centre-North, the South-West and Centre-East regions of Burkina Faso, respectively. Only 136 birds in the Centre-East region were from the Konde ecotype (Photo 1). The approach was to identify local chicken farmers with a traditional system (free-ranging chickens) and reasonable number (>100 birds per ecotype) of breeding birds as suggested by Besbes[13]. Moreover, optimal distance (20 km) from other sites was also checked to avoid sampling related problems.

Measurements: A qualitative and quantitative criteria for animal species suggested by Besbes[13] was used for the phenotypic characterization of the chickens. Qualitative parameters of birds [sex (female and male), eye color (white, Black and white, Yellow, Maroon, black, orange, red, red maroon, red orange) (photo 2), color (black, black with white spots, red, pink) and shape (round, oval) of barbels, crest shape (pea crest, rosaceous, simple), appearance of auricles (round, oval), beak shape (curved, straight), feather distribution and structure, skin color (dark white, white, black, orange, pink), plumage color (photo 2-4)] were assessed. Sex was determined based on external characteristics, in particular the distinctive features between males and females (presence of dewclaws, development of the crest and tail carriage).

The quantitative parameters of birds (length of beak, neck, body, outstretched wings, thighs, legs and tarsi) were measured (photo 5). These length measurements were assessed as fellow:

- **Body length:** Distance from the tip of the upper mandible to the tip of the tail (without feathers)
- **Neck length:** Distance from the base of the head to the starting point of the thorax above the crop
- **Beak length:** Distance from the tip of the upper mandible to the corner of the two mandibles
- **Thigh length:** Distance from the knee joint to the tibio-tarsal joint

Photo 1: Konde chicken ecotype (a rooster and two hens)

Photo 2(a-b): Description of some parts of the head. (a) Chicken naked neck and (b) Curly chicken

- **Leg length:** Taken between the coxo-femoral joint and the tibiofemoral joint
- **Tarsus length:** Taken between the femorotibial joint and the tarsometatarsal joint (emission zone of the fingers)
- **Wing length:** Length of the wing extended from the junction of the humerus to the spine to the tip of the wing

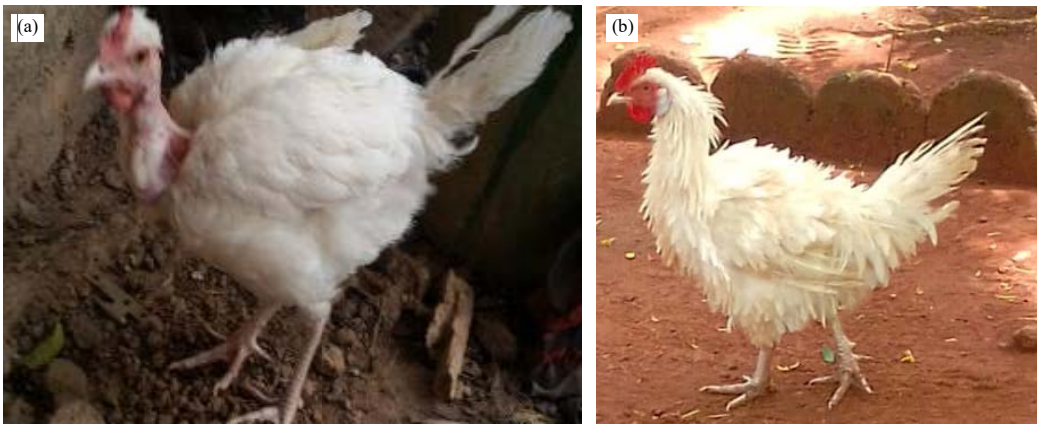

Photo 3(a-b): Distribution and structure of feathers (a) Chicken naked neck and (b) Curly chicken

Photo 4: Feathers observed in chicken

Photo 5: Shape and colour of tarsi

Different lengths were measured with the help of the tape. Body weight was measured using an electronic scale with a maximum capacity of 5000 g and an accuracy of 0.001 g.

Data analysis: Statistical analysis was performed using the R software (R.5.3.3) program. The descriptive statistics (frequency, means, standard deviations) were used to describe the characteristics of data and the Spearman rank correlation was used to measure the correlation between quantitative variables. The non-parametric tests (Kruskal Wallis and the Mann-Whitney) were used to assess the differences between the four local ecotypes and sex groups. Multivariate analyses (quadratic discriminant factor analysis and determination of Mahalanobis distance) were performed to identify the different populations and to group them.

RESULTS

Biometric characteristics: In Burkina Faso, the overall mean body weight (BW) was 1204.80±344.9 g and it varied significantly ($p<0.05$) across the four regions and sex classes (Table 1). Konde chickens ecotype were heavier (1651.85±378.57 g) than those of the Centre-North (1163.66±259.39 g) and the South-West (1217.92±322.31 g). The latter two ecotypes were heavier than that of the Sahel ecotype (1023.59±250.99 g). For all ecotypes, males were significantly heavier (Konde = 2006.27±412.17 g; Centre-North = 1301.28±269.90 g; Sahel = 1123.82±294.22 g; South-West = 1470.35±349, 62 g) compared to female birds (Konde = 1498.89±234.74 g; Centre-North = 1080.08±213.67 g; South-West= 1096.31±223.17 g; Sahel = 956.77±190.98 g).

Table 1 indicates, bill length (BBB), neck length (NL), body length (BL) and wing length (WL) were significantly different across the regions and sex groups. The beak (3.64±0.40 cm), body (39.22±4.43 cm) and wing (21.17±2.08 cm) length of Konde chickens were significantly ($p<0.05$) longer than those of the Centre-North, Sahel and South-West region, which differed significantly ($p<0.05$) from each other for these three parameters. The neck was significantly longer in Konde ecotype birds (18.39±2.46 cm) compared to those of the South-West (13.74±2.10 cm), which had a higher value than those of the North-Central (12.51±1.91 cm) and Sahel (12.08±1.75 cm). The latter two ecotypes did not differ from each other in neck length. Across sex groups, males had longer beak, body, wing and neck compared to females (Table 1).

Thigh, tarsal and leg lengths were significantly different ($p<0.05$) between region and sex classes (Table 1). Local Konde ecotype birds had higher values for these parameters than those of the Centre-North, the South-West and the Sahel regions. Similarly, the Konde ecotype birds had

Table 1: Biometric characteristics of local chicken by region and sex

Parameters	Sex	Centre-East (Kondé)	Centre-North	Sahel	South-West	General mean
BW (g)	Female	1498.89±234.74^{b}	1080.08±213.67^{b}	956.77±190.98^{b}	1096.31±223.17^{b}	1110.58±265.82^{b}
	Male	2006.27±412.17^{a}	1301.28±269.90^{a}	1123.82±294.22^{a}	1470.35±349.62^{a}	1375.07±401.84^{a}
	mean	1651.85±378.57^{a}	1163.66±259.39^{b}	1023.59±250.99^{c}	1217.92±322.31^{b}	1204.80±344.90
BBB (cm)	Female	3.47±0.35^{b}	3.10±0.29^{b}	2.42±0.21^{a}	3.02±0.23^{b}	2.97±0.42^{b}
	Male	4.02±0.20^{a}	3.39±0.41^{a}	2.49±0.15^{a}	3.20±0.32^{a}	3.15±0.55^{a}
	mean	3.64±0.40^{a}	3.21±0.37^{b}	2.45±0.19^{c}	3.08±0.28^{d}	3.03±0.48
NL (cm)	Female	17.41±1.99^{b}	11.89±1.55^{b}	11.26±1.23^{b}	13.16±1.94^{b}	12.90±2.52^{b}
	Male	20.66±1.88^{a}	13.53±2.02^{a}	13.31±1.71^{a}	14.93±1.92^{a}	14.61±2.83^{a}
	mean	18.39±2.46^{a}	12.51±1.91^{b}	12.08±1.75^{b}	13.74±2.10^{c}	13.51±2.76
BL (cm)	Female	37.38±2.95^{b}	25.18±4.40^{b}	17.13±1.02^{b}	34.88±3.21^{b}	28.39±8.22^{b}
	Male	43.48±4.37^{a}	28.70±5.29^{a}	18.69±1.65^{a}	38.78±4.12^{a}	30.59±9.68^{a}
	mean	39.22±4.43^{a}	26.51±5.05^{b}	17.75±1.52^{c}	36.15±3.97^{d}	29.18±8.83
WL (cm)	Female	20.25±1.52^{b}	16.32±1.16^{b}	17.48±1.60^{b}	16.57±1.47^{b}	17.16±1.89^{b}
	Male	23.29±1.62^{a}	17.94±1.57^{a}	20.34±2.19^{a}	18.87±1.79^{a}	19.41±2.41^{a}
	mean	21.17±2.08^{a}	16.93±1.54^{b}	18.62±2.33^{c}	17.32±1.91^{d}	17.96±2.35
THL (cm)	Female	9.66±0.79^{b}	9.40±0.56^{b}	7.59±1.12^{b}	9.24±1.46^{b}	8.97±1.34^{b}
	Male	11.10±0.92	9.88±0.60	8.47±0.81	10.28±1.59	9.74±1.37^{a}
	mean	10.10±1.06^{a}	9.58±0.62^{b}	7.94±1.09^{c}	9.58±1.58^{b}	9.24±1.40
TTL (cm)	Female	9.10±0.75	7.45±1.78	6.61±0.51	7.45±1.28	7.47±1.46^{b}
	Male	11.22±0.91	8.36±1.07^{b}	8.09±0.90^{b}	9.01±1.70^{c}	8.77±1.53^{a}
	mean	9.74±1.26^{a}	7.80±1.61^{b}	7.20±1.00^{c}	7.96±1.60^{b}	7.93±1.61
LL (cm)	Female	13.62±1.71^{b}	12.23±1.82^{b}	11.32±0.80^{b}	11.67±1.16^{b}	12.00±1.56^{b}
	Male	15.90±1.74^{a}	14.23±2.23^{a}	13.27±1.18^{a}	13.46±1.65^{a}	13.89±1.92^{a}
	mean	14.31±2.01^{a}	12.98±2.21^{b}	12.10±1.36^{c}	12.26±1.58^{c}	12.67±1.92

Body weight (BW), Beak length (BBB), Neck length (NL), Body length (BL) and Wing length (WL), Thigh length (THL), Tarsal length (TL), Leg length (LL). Values bearing different letters are significantly different at the 5% threshold in contrast to letters that are identical for each parameter and sex per region

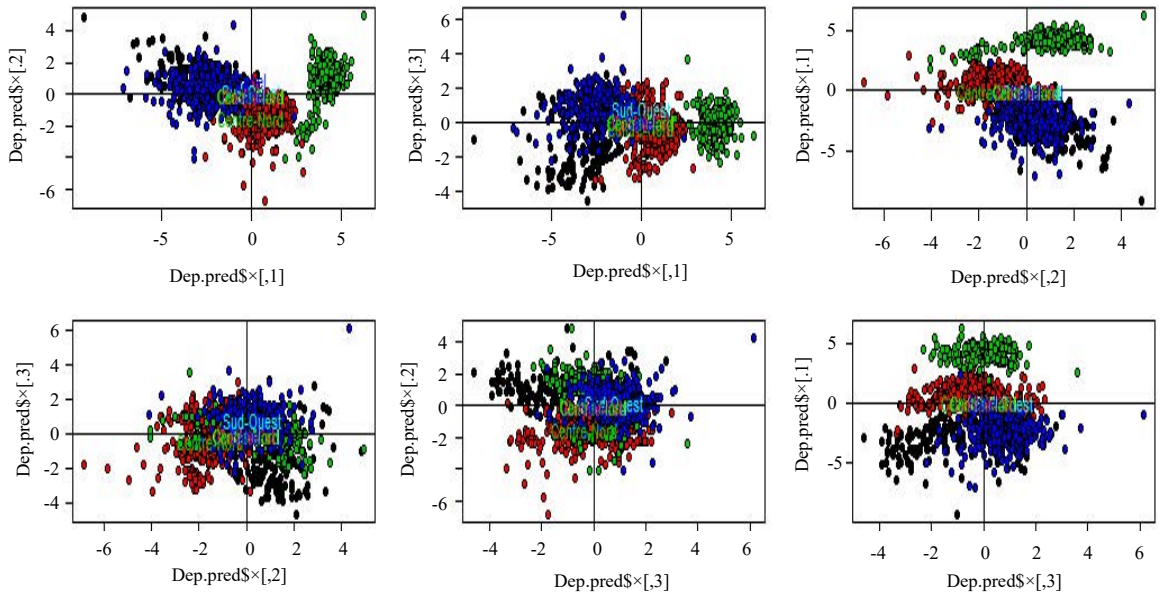

Fig. 2: Factorial design according to the three axes

Black color: Centre-East, Blue color: South West, green color: Sahel, red color: Centre-North; number of axes: 1;2;3

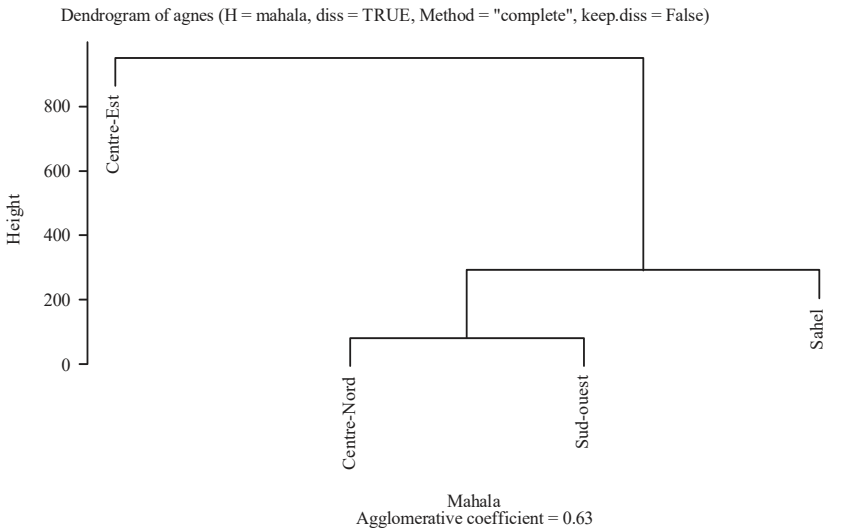

Fig. 3: Dendrogram of the mahalanobis distance between regions

longer legs compared to their counterparts in Centre-North regions. The latter had higher values than those of the Sahel(12.10±1.36 cm) and South-West (12.26±1.58 cm) regions. The thigh, tarsus and leg of males were significantly ($p<0.05$) longer than those of females.

Of the eight variables (body weight and lengths of beak, neck, body, wing, thigh, tarsal and leg), body, wing, beak and leg lengths had higher discriminating power between the different ecotypes. The Mahalanobis distance was used for the ascending hierarchical classification and grouping of birds from four regions and across the three agro-ecological zones into three distinct sub-populations (Fig. 2 and 3). Based on such distance, sub-population 3 consisting of Konde ecotype birds in the Centre-East was clearly separated from the other two sub-populations. Furthermore, sub-population 1 (chicken in Sahel region) was different from the sub-population 2 that included birds from the Centre-North and South-West regions. Characteristics of three identified sub-populations

are presented in Table 2. The mean body weight was 909.42±118.52 g, 1296.29±162.83 g and 1976.66±273.04 g for the three sub-populations, respectively. The correlations between body weight and other measurement criteria ranged from 0.20-0.64 (Fig. 4).

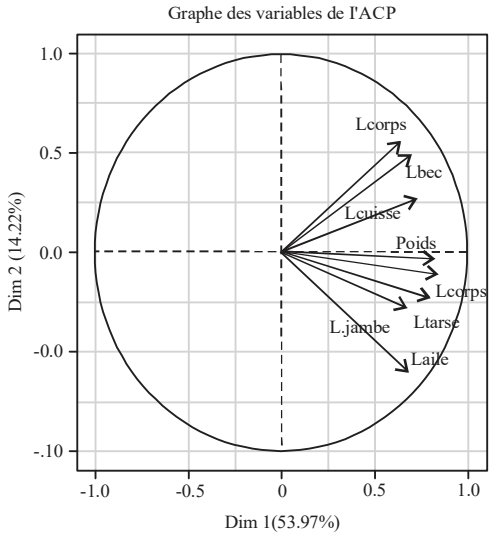

Fig. 4: Correlations between quantitative variables

Qualitative morphological characteristics: Thirteen plumage colors (white, partridge, multi-colors, ermine, black, wheat, yellow/wild, cuckoo, pebbled, red, salmon, grey, golden) were identified and grouped into three classes (golden, copper and silver) as indicated in Table 3. The dominant plumage colors across all chicken sub-populations were white (15.86%), partridge (11.96%), mille-fleur (11.79%), ermine (10.09%), black (7.8%), pebbled (7.8%), cuckoo (7.55%), salmon (6.96%). Other colors with less than 6% abundance per region were red, grey, golden, wheat and yellow/purple.

Table 2: Characteristics of three identified populations

	Mean±SD		
Characteristics	Population 1	Population 2	Population 3
LL (cm)	11.96±1.58	12.88±1.80	14.62±2.29
WL (cm)	16.93±1.87	18.16±2.04	15.81±2.29
BL (cm)	25.21±8.05	30.55±7.84	38.70±7.56
THL (cm)	8.54±1.21	9.55±1.29	10.57±1.11
BBB (cm)	2.79±0.38	3.13±0.43	3.54±0.52
TL (cm)	7.09±1.26	8.21±1.43	10.01±1.49
NL (cm)	11.99±1.68	13.95±2.46	17.65±2.99
BW (g)	909.42±118.52	1296.29±162.83	1976.66±273.04

Body weight (BW), Beak length (BBB), Neck length (NL), Body length (BL) and Wing length (WL), Thigh length (THL), Tarsal length (TL), Leg length (LL)

Table 3: Color, type and distribution of plumage in chicken by region

					Sahel		South-West		Population	
	Centre-East (Kondé)		Centre-North		N	Total	N	Total	N	Total
Plumage	N	Total	N	Total	No.	Percentage	No.	Percentage	No.	Percentage
White	16	11.77	60	17.05	26	9.12	85	20.94	187	15.86
White silver	1	0.74		0.00		0.00		0.00	1	0.08
White golden		0.00	3	0.85	1	0.35		0.00	4	0.33
Pebble	8	5.88	70	19.89		0.00	14	3.45	92	7.80
Cuckoo	1	0.74	24	6.82	48	16.84	16	3.94	89	7.55
Golden Cuckoo		0.00	1	0.28	4	1.40		0.00	5	0.42
Golden	3	2.21	12	3.41	11	3.86	65	16.01	91	7.72
Weat		0.00	3	0.85	10	3.51	8	1.97	21	1.78
Golden weat	1	0.74		0.00	1	0.35		0.00	2	0.17
Grey	10	7.35	5	1.42		0.00	4	0.99	19	1.61
Hermine	12	8.82	51	14.49	21	7.37	35	8.62	119	10.09
Golden Hermine		0.00		0.00	2	0.70		0.00	2	0.17
yellow	2	1.47		0.00		0.00		0.00	2	0.17
Multicolor	19	13.97	39	11.08	30	10.53	51	12.56	139	11.79
black	10	7.36	15	4.26	42	14.74	25	6.16	92	7.8
Copper black		0.00	1	0.28		0.00		0.00	1	0.08
Silver black	6	4.41	12	3.41		0.00		0.00	18	1.53
Golden black		0.00		0.00	1	0.35		0.00	1	0.08
Partridge	16	11.76	28	7.95	22	7.72	75	18.47	141	11.96
Silver partridge		0.00		0.00	1	0.35		0.00	1	0.08
Golden red		0.00		0.00	2	0.70		0.00	2	0.17
Silver red		0.00		0.00	1	0.35		0.00	1	0.08
Red	14	10.29	5	1.42	22	7.72	10	2.46	51	4.32
Salmon	7	5.15	22	6.25	35	12.28	18	4.43	82	6.96
Golden Salmon	10	7.35	1	0.28	5	1.75		0.00	16	1.36
Total general	136	100.00	352	100.00	285	100.00	406	100.00	1179	100.00

Table 4: Type and distribution of feathers in chicken according to region and sex

		Centre-Est		Centre-North		Sahel		South-West		Population	
		N	Total	N	Total	N	Total	N	Total	N	Total
		No.	Percentage	No.	Percentage	No.	Percentage	No.	Percentage	No.	Percentage
Feathers distribution	Crested	26	19.12	0	0	0	0.00	0	0.00	26	2.21
	Normal	110	80.88	352	100	284	99.65	386	95.07	1132	96.01
	Naked neck	0	0.00	0	0	1	0.35	20	4.93	21	1.78
	Total	136	100.00	352	100	285	100.00	406	100.00	1179	100.00
Feather structure	Curly	0	0.00	0	0	3	1.05	42	10.34	45	3.82
	Smooth	136	100.00	352	100	282	98.95	364	89.66	1134	96.18
	Total	136	100.00	352	100	285	100.00	406	100.00	1179	100.00

N: Total sample size, No: Sample size per variable

Table 5: Shape and coloring of comb, eyes

		Centre-East (Kondé)		Centre-North		Sahel		South-West		Population	
		N	Total	N	Total	N	Total	N	Total	N	Total
Comb shape		No.	Percentage	No.	Percentage	No.	Percentage	No.	Percentage	No.	Percentage
	Rose	3	2.21	0	0.00	14	4.91	21	5.17	38	3.22
	Single	133	97.79	352	100.00	271	95.09	385	94.83	1141	96.78
	Total	136	100.00	352	100.00	285	100.00	406	100.00	1179	100.00
Comb colors	white	0	0.00	1	0.28	0	0.00	0	0.00	1	0.08
	black	3	2.21	4	1.14	2	0.70	3	0.74	12	1.02
	Red	84	61.76	249	70.74	118	41.40	257	63.30	708	60.05
	Pink	38	27.94	90	25.57	142	49.83	122	30.05	392	33.25
	Reddish	11	8.09	8	2.27	23	8.07	24	5.91	66	5.60
	Total	136	100.00	352	100.00	285	100.00	406	100.00	1179	100.00
Eyes colors	white	0	0.00	0	0.00	0	0.00	1	0.25	1	0.08
	Black and white	1	0.74	2	0.57	5	1.75	1	0.25	9	0.76
	Yellow	1	0.74	163	46.31	1	0.35	6	1.48	171	14.50
	Maroon	4	2.94	29	8.26	21	7.37	39	9.61	93	7.89
	black	0	0.00	0	0.00	0	0.00	2	0.49	2	0.17
	Orange	125	91.91	121	34.37	0	0.00	318	78.33	564	47.85
	Red	0	0.00	0	0.00	0	0.00	1	0.25	1	0.08
	Red maroon	4	2.94	37	10.54	6	2.11	23	5.67	70	5.94
	Red orange	1	0.74	0	0.00	252	88.42	15	3.69	268	22.73
	Total	136	100.00	352	100.00	285	100.00	406	100.00	1179	100.00

N : Sample size per trait

The distribution of feathers shows that 80% of the plumage was normal feathered for each region (Table 4). Crested chickens (2.21%) were found mainly in the Konde ecotype in Centre-East region, while naked neck chicken (1.78%) were found only in the Sahel and South-West regions of Burkina Faso. In all regions, the smooth feather type represented more than 96%, while the curly feathers (3.82%) were found only in the Sahel and South-West regions.

Shape and color of the comb: Across the four regions, the dominant crest color was the red (60.05%) followed by the pink (33.25%). The majority of chicken had a single comb (96.78%) with a small proportion of chicken with a rose comb (Table 5).

Eye color: The main eye coloration was orange (47.85%) followed by orange-red (22.73%) and yellow (14.50%). The white and red colors were absent in the Konde birds and in the chickens of the Centre-North and Sahel regions. On the other hand, only the orange-red color was absent in the chickens of the Centre-North (Table 5).

Form and color of mump: The most frequent mumps colors encountered were white (54.88%), red (29.18%) across all regions (Table 6). Mumps were round (87.02%) or oval (12.98%). The percentage of round mumps was 100, 67.65, 78.69 and 91.63% in Sahel, Centre-East, Centre-North and South-West regions, respectively.

Shape and color of barbel: The main barbel colorations were red (64.21%) and pink (33.16%), black spotted with white (2.54%) and black (0.08%) color was present only in chicken from the South -West region. The barbels were

Table 6: Shape and coloring of mumps, barbells and beak

		Centre-East (Kondé)		Centre-North		Sahel		South-West		Population	
		N	Total	N	Total	N	Total	N	Total	N	Total
Mumps color	White	113	83.09	222	63.07	2	0.7.0	310	76.35	647	54.88
	Yellow	1	0.74	0	0.00	0	0.00	0	0.00	1	0.08
	Black	0	0.00	0	0.00	1	0.35	0	0.00	1	0.08
	Orange	1	0.74	20	5.68	0	0.00	0	0.00	21	1.78
	Red	21	15.44	110	31.25	127	44.56	86	21.18	344	29.18
	Pink	0	0.00	0	0.00	155	54.39	10	2.46	165	13.99
	Total	136	100.00	352	100.00	285	100.00	406	100.00	1179	100.00
Mumps shape	Orange	44	32.36	75	21.31	0	0.00	34	8.37	153	12.98
	Red	92	67.65	277	78.69	285	100.00	372	91.63	1026	87.02
	Total	136	100.00	352	100.00	285	100.00	406	100.00	1179	100.00
Barbells color	Black	0	0.00	0	0.00	0	0.00	1	0.25	1	0.08
	Black with white spots	2	1.47	2	0.57	10	3.51	16	3.94	30	2.54
	Red	101	74.26	256	72.73	127	44.56	273	67.24	757	64.21
	Pink	33	24.26	94	26.70	148	51.93	116	28.57	391	33.16
	Total	136	100.00	352	100.00	285	100.00	406	100.00	1179	100.00
Barbells shape	Oval	131	96.32	216	61.65	163	57.19	264	65.02	775	65.74
	Round	5	3.68	135	38.35	122	42.81	142	34.98	404	34.26
	Total	136	100.00	352	100.00	285	100.00	406	100.00	1179	100.00
Beak color	white	0	0.00	55	15.63	98	34.39	102	25.12	255	21.63
	horned	13	9.56	17	4.83	0	0.00	0	0.00	30	2.54
	yellow	0	0.00	0	0.00	0	0.00	15	3.37	15	1.27
	White with maroon spots	36	26.47	99	28.13	13	4.56	102	25.12	250	21.21
	White with black spots	59	43.38	66	18.75	11	3.86	113	27.83	249	21.12
	maroon	11	8.09	12	3.41	3	1.05	23	5.67	49	4.16
	Pink	0	0.00	1	0.28	18	6.32	9	2.22	28	2.37
	black	17	12.50	102	28.98	142	49.82	42	10.34	303	25.70
	Total	136	100	352	100.00	285	100.00	406	100.00	1179	100.00
Beak shape	curved	136	100	352	100.00	285	100.00	376	92.61	1149	97.46
	straight	0	0	0	0.00	0	0.00	30	7.39	30	2.54
	Total	136	100	352	100.00	285	100.00	406	100.00	1179	100.00

oval (65.74%) or round (34.26%). In the Konde ecotype birds, more than 96% of the barbels were oval (Table 6).

Shape and color of the beak: Beak color (maroon, black, white, maroon spotted, black spotted, pink, yellow and horn beak) varied across regions. The most frequent colors were black (25.70%), white (21.63%), maroon spotted (21.21%) and black spotted (21.12%). Maroon, pink, yellow and hornbill colors were less abundant with a frequency lower than 5%. Pink and white colors were absent in local Konde birds (Table 6). The yellow coloration was only present in chicken from South-West region. The horn beak was present only in Konde ecotype and birds in the Centre-North region. The vast majority of beaks were curved (97.46%) and only 2.54% were straight. The beak was curved in all (100%) of the Konde ecotype and birds in the Centre-North and the Sahel regions. The straight beaks were found only in the South-West region.

Shape and color of the tarsi: All tarsi (100%) were flat across the four regions (Table 7). The tarsal colors encountered were grey (49.45%), white (29.01%) and black (17.56%) across the different ecotypes. White legs were absent in the Konde birds while 96.32% of the birds had grey legs in the same sub-population. Yellow and pink legs were only found in the South-West region. The skin colors encountered were dirty white (93.64%), pink (6.11%), black (0.08%), orange (0.08%) and white (0.08%). Skin color varied across the regions as presented in Table 7.

DISCUSSION

Biometric characteristics: Konde chickens showed significantly higher values ($p<0.05$) than those of the birds in the other three regions for the quantitative parameters measured. The Konde chickens were larger and heavier than those of the birds from the Centre-North, Sahel and South-West regions. As expected, males were significantly heavier than females. Similarly, the other parameters measured confirmed the significant sexual dimorphism across the four regions. The average body weight of local roosters and hens of the Konde ecotype were higher than those of the local chicken as reported by Pinde *et al.*[10] in the

Table 7: Shape and color of tarsi and skin color of local chicken by region in percent

		Centre-East (Kondé)		Centre-North		Sahel		South-West		Population	
		N	Total	N	Total	N	Total	N	Total	N	Total
		No	Percentage	No	Percentage	No	Percentage	No	Percentage	No	Percentage
Tarsi color	White	0	0.00	111	31.53	70	24.56	161	39.66	342	29.01
	Grey	131	96.32	104	29.55	171	60	177	43.60	583	49.45
	Yellow	0	0.00	0	0.00	0	0.00	19	4.68	19	1.61
	Black	5	3.68	137	38.92	44	15.44	21	5.17	207	17.56
	Pink	0	0.00	0	0.00	0	0.00	28	6.90	28	2.37
	Total	136	100.00	352	100.00	285	100.00	406	100.00	1179	100.00
Tarsi shape	flattened	136	100.00	352	100.00	285	100.00	406	100.00	1179	100.00
	Total	136	100.00	352	100.00	285	100.00	406	100.00	1179	100.00
Skin color	Dark white	64	47.06	350	99.43	284	99.65	406	100.00	1104	93.64
	White	0	0.00	0	0.00	1	0.35	0	0.00	1	0.08
	Black	0	0.00	1	0.28	0	0.00	0	0.00	1	0.08
	Orange	1	0.74	0	0.00	0	0.00	0	0.00	1	0.08
	Pink	71	52.21	1	0.28	0	0.00	0	0.00	72	6.11
	Total	136	100.00	352	100.00	285	100.00	406	100.00	1179	100.00

Sudanian zone (males = 1640±20 g, females = 1115±10 g), by Fotsa *et al.*[14] in Cameroon (males = 1665±403 g, females = 1259±16 g), by Moula *et al.*[15] in the Kabylie region in Algeria (males = 1427±18 g, females = 1144±18 g), by Dahloum *et al.*[16] in north-eastern Algeria (males = 1716±17.53 g, females = 1451± 10.41 g) and by Getu *et al.*[17] in Ethiopia (males = 1630± 300 g, females = 1370± 200 g). However, they were lower than those reported for Konde chickens by Ouandaogo cited by Keambou *et al.*,[9] in Burkina Faso (males = 2500; females = 1800g), for local chickens by Jesuyon and Salako[18] in Nigeria (males = 2400±140 g, females = 1500±140 g) and by Guni *et al.*[19] in Tanzania (Males = 2095±29.9 g, females = 1525 ± 15.9 g). Similar results confirming the higher sexual dimorphism in Konde chickens compared to birds in the Centre-North, Sahel and South West regions was observed based on other measured parameters. This sexual dimorphism was also observed in Cameroonian chicken ecotypes[9] and can be explained by the faster growth of males compared to females. The present study suggest that a selection program on the basis of the growth traits would be more advantageous with males than females[9], especially in Konde ecotype. These significant differences could be explained by several sources of variation including genetic and environmental factors. The morpho-weight variations observed in local chicken can be attributed to differences in animal husbandry (i.e. feeding, health monitoring), management, uncontrolled crossbreeding with exotic strains, availability of feed and feed supplements[20] and to the climatic characteristics of each geographical region[21]. The environment and the breeding period can also show the differences in zootechnical performance. On-station studies[9,22] showed higher zootechnical performance than those of the studies conducted under regular farming conditions[9,14,23].

Multivariate analyses: Chicken from the Centre-North and South-West regions were more similar in their characteristics resulting in an intermediate sub-population between the Konde and Sahel chickens. In the current study, three populations were identified in contrast to a previous study conducted by Pinde *et al.*[10] who found only two sub-populations. This difference in the number of sub-populations may be due to the difference in the sample sizes of the Konde chicken between these two studies. Sub-population 1 was more homogeneous than those of the other two sub-populations (2 and 3) confirming the result of Pinde *et al.*[10] who found a higher homogeneity in the sub-population of Sahel zone bird.

Morphological characteristics: There was a significant variability in plumage color, feather type and distribution across the four regions which could be associated with genetic variation. These results were not different from those found in Burkina Faso[10], other African countries[9,14,24] and in Asia[7]. Variation in plumage color was due to the effect of genes and their interactions[25]. Multiple uncontrolled crosses over several decades between animals with different plumage colors gave rise to other color combinations that exist in low proportions[9]. For feather distribution, normal (wild type N), crested (locus Cr) and naked neck (locus Na) phenotypes were observed in our study areas. The normal feather was the most frequent. The feather distribution found in the study

populations was due to interaction between genotype and environment[14]. Thus, the widely represented full normal feathering would be the consequence of the relative homogeneity of geoclimatic conditions or of selection by breeders in Burkina Faso. Two dominant feather types such as smooth feathers (wild type) and curly feathers (locus F) were identified. These results were different from those obtained in Burkina Faso[10]. The dominant (smooth) plumage of chicken in this study was found to be under the control of the f+ allele (f+*f+/f+*f+: wild type)[26]. Naked-necked and curly chicken are mainly found in south-west Burkina in agreement with the results reported by Ouandaogo cited by Keambou *et al.*,[9] in Burkina Faso.

Head anatomy: The great diversity in eye, comb, beak and appendage colors between the four regions is likely to be due to genetic variability. The predominant comb colors were red followed by pink in all areas. The majority of birds had a single comb (wild type S locus) with a small proportion of chicken with a rose comb shape (R locus). The single comb was the most common, followed by the rose shape. A previous study[26] associated the rose comb (R) with reduced fertility in homozygous (RR) males due to reduced sperm viability compared to the other genotypes. White and red mumps were the most frequent. Pink mumps were found only in the Sahel and South-West regions, while the orange mumps were found in local Konde chicken and birds in the Centre-North region. Yellow and black mumps ware rare and present in the Centre-East and the Sahel region birds, respectively. Mumps ware mostly round and Red and pink are the most frequent barbels colors. Oval barbels ware predominant compared to round ones. Beak coloration varies according to region. The black bill is predominant, followed by white, brown spotted and black spotted. The yellow coloring is only present in chicken from the South-West region. The shape of the beak is curved for all chicken in the study except for chicken in the South-West region where straight beaks were observed. The main eye colors were orange followed by orange-red and yellow. Few studies have focused on genes responsible for eye color. According to Coquerelle[26], it is influenced by interactions between alleles at the extension (E) and barring (B) inhibitors of dermal melanin and the brown eye (BR) loci. The multiplicity of tarsi and skin colors within our study areas certainly indicates the existence of genetic variability. Grey (wild type), white (Id or y locus) and black (MI E) tarsi are most common. Konde chicken had predominantly grey legs followed by black legs. According to Coquerelle[26], the white color of the tarsi is influenced by the W*N or W+ (white: wild type) allele. The yellow legs (ID W) were only found in the South-West region, which borders Cote d'Ivoire and Ghana. The tarsi were flat for all birds across the four studies areas. The presence of yellow-legged birds can be explained by the introduction of commercial strains[26]. The frequent skin color is dirty white. These results agree with some previous studies conducted in Cameroon[9] and Benin[26]. Pink was only found in the Konde ecotype of chicken as opposed to chicken from the South-West region which had dark white skin (ID).

CONCLUSION

Local chicken in Burkina Faso are characterized by a substantial phenotypic diversity. The phenotypic diversity is manifested by the multiplicity of colors of the plumage, tarsi, skin, heads' parts, appendages and the type and distribution of feathers on body. Naked neck, curly and crested plumage, yellow legs and rose comb mutations are poorly represented in our study sample. Konde chicken was particularly heavier and larger, especially the males which could be used as broilers. Konde Chicken showed significantly higher values for the studied quantitative parameters compared to local chickens in the other three regions. The intermediate sub-population consisted of chicken from the Central-North and South-West regions. Chicken from Sahel region constituted the third and more homogeneous sub-population characterized by light and small birds. Further genetic studies using molecular or pedigree-based information are needed for a better characterization of these different ecotypes and to assess the potential for future selection programs especially targeting Konde ecotype that was particularly heavier and larger.

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